

# *Sharing the electromagnetic spectrum*

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Spectrum sharing has gained national level attention as a way of furthering the economic exploitation of spectrum resources while protecting national security interests.

The electromagnetic spectrum is the medium that mobile phones, satellite communication systems, garage door openers, RADAR, and Wi-Fi devices operate within to send and receive information wirelessly.

It is not only important to our military forces and federal agencies, but an economically critical resource used by commercial companies around the world. It is this friction point that must be balanced at the national level to ensure adequate spectrum access for our forces to train on battlefield systems in the United States, while enabling the quickly developing market for mobile data to expand and innovate.

In an increasingly crowded space, spectrum sharing is emerging as one method to enable our forces and our nation's commercial needs to coexist.

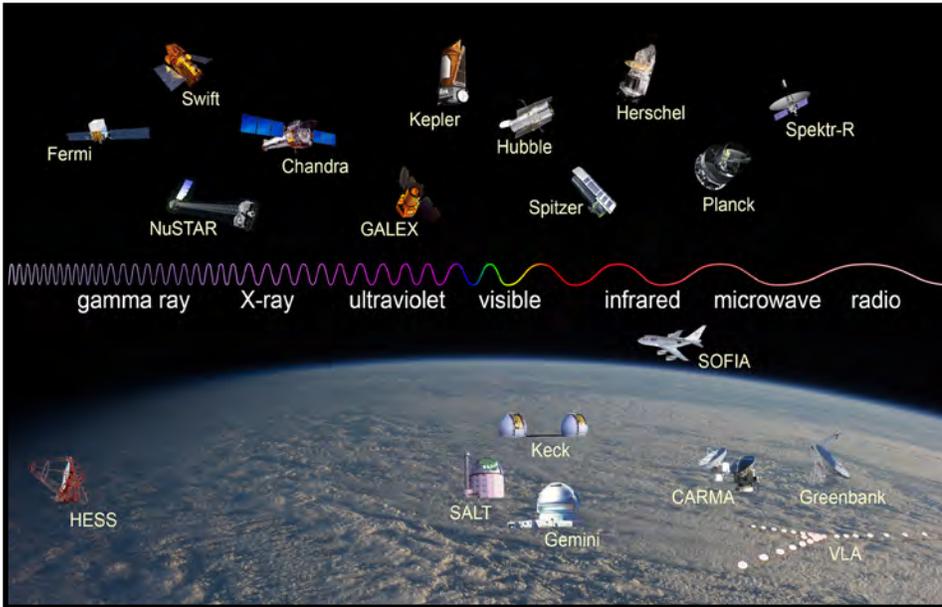
Federal spectrum management dates to the 1920s when radio broadcasts by federal and commercial stations and the subsequent interference between those stations, demonstrated a need for management of the resource.

Today, there are two agencies at the federal level that manage spectrum policy in the United States, the National Telecommunications and Information Administration and the Federal Communications Commission. The NTIA was established by executive order, and operates under the Secretary of Commerce to govern all radio transmissions made by

U. S. Government stations. The Federal Communications Commission was established by The Communications Act of 1934, and is responsible for regulating non-federal transmissions. Together, these entities provide spectrum management of all radio transmissions in the United States. These rules and regulations are codified in the Manual of Regulations and Procedures for Federal Radio Frequency Management - commonly called the "Red Book", which is published and updated by NTIA, and the Code of Federal Regulations Title 47 - Telecommunications, which are the rules created and managed by the FCC. At the international level, the International Telecommunications Union establishes rules for areas outside of the territorial limits of individual nations, and other nations establish their own rules for radio frequency operations within their borders.

Over time, the FCC and the NTIA developed bands of federal and non-federal allocated spectrum that allowed each agency to assign spectrum to their stakeholders, with minimal coordination. This spectrum segregation can most easily be seen in the Table of Frequency Allocations, in the NTIA Red Book Chapter 4, or the CFR Title 47, Part 2. The table has an international column (the U.S. is in Region 2), and a U. S. column, which is further split into two other columns signifying federal and non-federal tables. Instances where both of the columns indicate allocated radio-communication services identify shared spectrum, and frequency use in this band must be coordinated between the FCC and NTIA.

Modifications to the Allocation Table are made by NTIA with recommendations from the Interdepartmental Radio Advisory Committee, which is chaired by NTIA and



attended by a FCC liaison, and/or the issuance of a Report and Order by the FCC modifying the Code of Federal Regulations.

In recent years, there has been pressure placed upon national regulators to open up new spectrum for commercial use. In 2010, the White House released a Presidential Memorandum titled "Unleashing the Wireless Broadband Revolution", which requires federal agencies to make 500 MHz of spectrum available for commercial use within 10 years.

In July 2012, the President's Council of Advisors on Science and Technology issued a report concluding that "clearing government-held spectrum of Federal users and auctioning it for commercial use is not sustainable," and urges the President to direct spectrum sharing to meet the need

for commercial bandwidth. Finally, in June 2013, The White House released the Presidential Memorandum entitled "Expanding America's Leadership in Wireless Innovation."

This memorandum states that "sharing can and should be used to enhance efficiency among all users and expedite commercial access to additional spectrum bands." These three documents attempt to address the shortfall of available spectrum needed for continued wireless commercial systems by opening up federal bands to sharing with commercial systems.

The explosion of wireless systems in the last five years has created a critical need for more bandwidth to support the public's expanding desire for spectrum dependent systems such as tablets, smartphones, WI-FI access points, and a host of new

technologies that will allow vehicles, home appliances and heating/cooling systems and other items, collectively known as the internet of things, to operate.

This boom in wireless systems comes as technological means of passing more information over spectrum is bumping up against Shannon's Law. This law, written by engineer Claude Shannon in 1948, and outlined in the article "Shannon's Specter" by Kevin Fitchard, states that "the amount of error-free data that could be transmitted over a channel of any given bandwidth is limited by noise." The wireless industry has evolved their system's efficiency to pass more data over the same amount of spectrum, but has reached a level of efficiency that will require more spectrum to continue to expand download and upload speeds of wireless devices. This additional spectrum may well come through the sharing of existing government bands within which the Department of Defense operates.

A recent agreement on the 1755 - 1780 MHz band will result in the Department of Defense and other federal users clearing from that spectrum and relocating. The FCC will then auction this band as part of the Advanced Wireless Services

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auction. However, this clearing and moving is an expensive proposition for federal spectrum users. Cost estimates of moving all operations out of this band and relocating to another run to \$3.5 billion. To avoid the expense of future clearing of federal spectrum, the sharing model, proposed by the PCAST report and embraced by the June 2013 Presidential Memorandum, will enable new entrants to existing federal spectrum while protecting the operation of the incumbent federal systems.

Spectrum sharing between federal and non-federal users is not a new concept, and a short review of the National Table of Frequency Allocations will show many bands that are allocated to both types of use. Additionally, within various allocations federal users share the spectrum with other federal users, and non-federal with other non-federal users.

The bottom line of sharing spectrum is that, typically, it is not physically possible to share the same discreet frequency at the same time and geographic location. Therefore sharing is now accomplished by creating exclusion zones around users geographically to protect their spectrum usage according to the power and modulation of their signal.

What is new about spectrum sharing is that our ability to dynamically identify spectrum use through technical methods like dynamic frequency selection, cognitive radio and geo-location, spectrum managing databases will allow different types of services to share the same spectrum bands in real-time while avoiding harmful interference between operations. While each of these technologies has challenges, these and future, yet-to-be-developed technologies lay the groundwork for real-time, massively shared spectrum. To that end, there are two bands that are currently under review for sharing between federal and non-federal users, 3550-3650 MHz and portions of the 5 GHz bands.

The 3550-3650 MHz band is currently used by federal stations for Radiolocation Service and Aeronautical Radionavigation Service

(ground based), and by non-federal stations in the Fixed Satellite Service.

In the Notice of Proposed Rulemaking and Order, FCC 12-148, released in December 2012, the FCC proposed modifying the use of the band to include both licensed and unlicensed devices (think cell phones and WI-FI) across this band, while protecting the incumbent users, primarily federal radar use by the Navy, and Fixed Satellite use by commercial organizations. In their Fast Track report, in response to the Presidential Memorandum regarding spectrum sharing, the NTIA identified the band 3550-3650 MHz as a potential band that could be shared with commercial users.

The FCC added 50 MHz, 3650-3700 MHz to consideration in its proposed rulemaking. This band has a low propagation characteristic, meaning its range is less than for signals at lower frequency ranges. According to the NPRM, this characteristic makes it "well-suited to spectrum sharing, particularly geographic sharing". This sharing would be facilitated by the lower propagation of signals in the band, which makes it suitable for small cells.

The NPRM identified a multi-tiered licensing and interference protection framework to three types of users, or tiers, "Incumbent Access, which would include authorized federal and grandfathered FSS users." Priority Access would include users with a quality-of-service requirement. Finally, the General Authorized Access would consist of users with an opportunistic access to the spectrum. Each tier would get interference protection from the next lower tier, from Incumbent to PA to GAA. This interference protection would come from a Spectrum Access System.

The SAS would govern interactions between the tiers within the band. PA and GAA users may be silenced, or limited in operating power or geographic operating location when an incumbent comes up for operation, and the GAA will be required not to interfere when it operates. This design builds upon the Television White

Space program, which uses databases to enable sharing of bandwidth cleared when digital television stations replaced analog stations. However, the SAS envisioned for use in the 3.5 GHz band is much more dynamic and therefore a more complex system.

The rules on how this band will ultimately be used are still being written, and collaboration between NTIA and the FCC is ongoing, but there is an emerging value in this sharing model for the U.S. Army. As the allocation tables are modified to allow federal and non-federal sharing in the 3.5 GHz band, there will be opportunities for the Army to obtain commercially created communication systems for high-speed data transfer to mobile devices, and get spectrum to train at both home bases and overseas locations that have similarly harmonized allocations. It is difficult to use current 4G LTE systems because, while the systems are available, the spectrum for U.S. systems was auctioned to telecom service providers for their commercial use. The future developments in the 3.5 GHz band may provide access to civilian technology with the spectrum to use it.

Unlicensed National Information Infrastructure devices provide short-range, high-speed unlicensed wireless connections in the 5 GHz band for, among other applications, Wi-Fi-enabled

radio local area networks, cordless telephones, and fixed outdoor broadband transceivers used by wireless internet service providers. Unlicensed wireless broadband systems have become critical complements to licensed commercial mobile networks and to fixed wireline networks. For example, smart phones, tablets, net-books and laptops typically have inexpensive Wi-Fi capabilities that enable high-speed broadband connectivity in a wide array of locations.

Part 15 of the Federal Communications Commission's rules permits the operation of radio frequency devices without issuing individual licenses to operators of these devices. The Commission's Part 15 rules are designed to ensure that there is a low probability that these devices will cause harmful interference to other users of the same or adjacent spectrum.

Typically, unlicensed devices operate at very low power over relatively short distances, and often employ various techniques, such as dynamic spectrum access or listen-before-talk protocols, to reduce the interference risk to others as well as themselves. The primary operating condition for unlicensed devices is that the operator must accept whatever interference is received and must correct whatever interference it causes. Should harmful interference occur,

the operator is required to immediately correct the interference problem or cease operations.

Beginning in 1997, the FCC continually took actions that would eventually make available 555 megahertz of spectrum in the 5 GHz band which is divided into several sections referred to as U-NII bands. The UNII-1 band 5.15-5.25 GHz was originally designated for indoor operations, UNII-2 and UNII-2A extended bands 5.25-5.35 GHz are for indoor and outdoor operations, and the UNII-3/ISM band 5.725-5.825 GHz is intended for outdoor bridge products and may be used for indoor WLANs as well. In a more recent attempt to satisfy the growing needs of businesses and consumers for fixed and mobile broadband communications, the FCC published its First Report and Order on April 1, 2014 which slightly modified the rules for UNII-1 devices in the 5.15-5.25 GHz band; removing the indoor-only restriction and increasing the permitted power, thus increasing the utility of spectrum and accommodating the next generation of Wi-Fi technology.

In order to co-exist with military radar systems in the 5 GHz UNII-2A extended bands, radios must comply with two features that are part of the IEEE 802.11

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which are Dynamic Frequency Selection and Transmitter Power Control. DFS dynamically instructs a transmitter to switch to another channel whenever a particular condition (such as the presence of a radar signal) is met. Prior to transmitting, a device's DFS mechanism monitors its available operating spectrum, listening for a radar signal. If a signal is detected, the channel associated with the radar signal will be vacated or flagged as unavailable for use by the transmitter. TPC is a feature of a digital microwave radio link that adjusts transmitter output power based on the varying signal level at the receiver. TPC allows the transmitter to operate at less than maximum power for most of the time; when fading conditions occur, transmit power can be increased as needed until the maximum is reached.

The Army, Navy, and Air Force operates Unmanned Aviation Systems in the 5 GHz frequency range for intelligence, surveillance, and reconnaissance; combat search and rescue; and real-time full-motion video for target development. The Department of Homeland Security also operates UASs in this band for drug interdiction and border surveillance operations. In addition, NASA also operates a limited number of systems in the 5.35-5.47 GHz band that are used for downlink transmissions of data to ground control receivers. The Department of Defense uses the 5.35-5.47 GHz band for a wide variety of ground based, shipborne, and airborne radars.

In 2012 Congress passed "Middle Class Tax Relief and Job Creation Act", in which section 6406(b)(1) required the NTIA in consultation with the Department of Defense and other impacted agencies, to conduct a study evaluating known and proposed spectrum-sharing technologies and the risk to federal users if the FCC allowed U-NII devices to operate in the 5350-5470 MHz and 5850-5925 MHz bands. Under current FCC regulations, U-NII devices are authorized to use 555 megahertz of spectrum in the 5150-5350 MHz

and the 5470-5825 MHz bands subject to specific technical and operational restrictions to enable sharing with protected radar and satellite operations.

On February 20, 2013 by notice of NPRM, the FCC proposed to amend Part 15 of its rules governing the operation of Unlicensed National Information Infrastructure (U-NII) devices in the 5 GHz band. As stated, U-NII devices are unlicensed intentional radiators that operate in the frequency bands 5.15-5.35 GHz and 5.47-5.825 GHz, and which use wideband digital modulation techniques to provide a wide array of high data rate mobile and fixed communications for individuals, businesses, and institutions. The FCC wanted to revisit the original 1997 rules, and proposed to modify certain technical requirements for U-NII devices to ensure that these devices do not cause harmful interference and thus can continue to operate in the 5 GHz band and make broadband technologies available for consumers and businesses.

The FCC also sought comment on making available an additional 195 megahertz of spectrum in the 5.35-5.47 GHz and 5.85-5.925 GHz bands for U-NII use. This could increase the spectrum available to unlicensed devices in the 5 GHz band by approximately 35 percent and would represent a significant increase in the spectrum available for unlicensed devices across the overall radio spectrum.

The initiation of this proceeding satisfies the requirements of Section 6406 (a) of the "Middle Class Tax Relief and Job Creation Act of 2012" which required the Commission to begin a proceeding to modify part 15 of title 47, Code of Federal Regulations, to allow unlicensed U-NII devices to operate in the 5350-5470 MHz band.

The Commission believes that an increase in capacity gained from 195 MHz of additional spectrum, combined with the ease of deployment and operational flexibility provided by the U-NII rules would continue to foster the development of new and innovative unlicensed devices, and increase wireless broadband access and investment.

Dialog between the Wireless Communication Industry, Cable Company Representatives, the FCC, and the NTIA are still underway in trying to create a permanent solution for spectrum sharing in the 5 GHz band. Industry representatives along with the Department of Defense are working tirelessly to meet the President's intent to increase spectrum availability for future technological advancement by 2020.

Discussions are also still on-going internally between the wireless and cable industry in negotiating more efficient spectrum usage within the U-NII bands while extending current outdoor/indoor wireless capabilities across the bands.

All federal and non-federal entities involved are diligently brainstorming to ensure the American people and Armed Forces abroad are getting the best possible

telecommunication service available while satisfying the growing need for future wireless technological advancement in the United States.

Spectrum is a commodity that fuels America's dominance in innovative commercial systems that power mobility. This same spectrum is needed by the Department of Defense to conduct its mission of protecting our nation and providing our warfighters with the systems they need to succeed on the battlefield. While on the face, these two aims appear to be mutually exclusive, through cooperative spectrum sharing and continued innovation in sharing techniques, we can achieve both a vibrant economic future and a dominant, technologically strong military force.

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Join the Discussion

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## ACRONYM QuickScan

**4G** - Fourth Generation  
**DFS** - Dynamic Frequency Selection  
**FCC** - Federal Communications Commission  
**FSS** - Fixed Satellite Service  
**GAA** - General Access Authorization  
**GHz** - Gigahertz  
**IEEE** - Institute of Electrical and Electronics Engineers  
**LTE** - Long-Term Evolution  
**MHz** - Megahertz  
**NPRM** - Notice of Proposed Rulemaking and Order  
**NTIA** - National Telecommunications and Information Administration

**NASA** - National Aeronautics and Space Administration  
**PA** - Priority Access  
**PCAST** - President's Council of Advisors on Science and Technology  
**RADAR** - Radio Detection and Ranging  
**SAS** - Spectrum Access System  
**TPC** - Transmitter Power Control  
**UAS** - Unmanned Aviation Systems  
**U-NII** - Unlicensed National Information Infrastructure  
**Wi-Fi** - Wireless Fidelity  
**WLANS** - Wireless Local Area Networks